Empirical Root Cause Analysis

CLEPA Warranty Conference 2015

Brussels

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28 May 2015

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Overview

- **Overview**
  - Introduction to root cause analysis
  - A *deus ex machine* approach to RCA
  - The scientific method
  - Box's iterative inductive-deductive process
  - Plan-Do-Check-Act
  - Exploratory data analysis
  - RCA helix
  - Examples
  - Customer/supplier information exchange

Root Cause Analysis

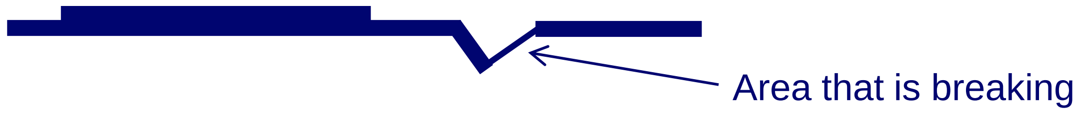
- Why perform a root cause analysis (RCA)?
  - To determine the root cause of the failure of a product or a process.
  - For process or product improvement.
    - We may want to know what is causing the current level of performance so we can improve it.
- There are many tools available for helping with a root cause analysis.
  - The Seven Quality Tools.
    - Ishikawa diagram, run chart, scatter plots, etc..
  - The Seven Management Tools.
    - Tree diagram, matrix diagram, etc…
  - Other tools and methods.
    - Calipers, microscopes, chemical titration, hammers, etc…

Root Cause Analysis

- A hypothetical example with a not so hypothetical consultant.
  - The hypothetical failure was a plastic component breaking during assembly.
  - The not so hypothetical consultant explained the “proper” way to perform a root cause analysis.
- “First you do an FMEA and then a QFD!”
  - “But shouldn't you look at the part? An RCA needs to be empirical.”
    - “A QFD is empirical, you need to go into production and look at the work instructions.”
- The example was around 1 out of 1000 parts breaking during assembly due to insufficient material thickness by design.

Root Cause Analysis

- Performing an FMEA or looking at work instructions are not necessarily wrong.
  - But actually looking at the defective component should not be neglected.



- The consultant is not alone in neglecting to actual look at the failed part.
  - Much of the literature on RCA explains why we should sit together as a team and use quality tools to analyze a failure.
    - The authors fail to mention the need to "talk to the part" as Dorian Shainin has said.
  - Team and tools are needed during an RCA, but the defective part should be a part of the team.

Root Cause Analysis

- Much RCA literature seems to have *deus ex machina* solutions.
  - According to the Merriam-Webster dictionary a *deus ex machina* is a:
    - “Stage device in Greek and Roman drama in which a god appeared in the sky by means of a crane (Greek, mechane) to resolve the plot of a play.”
  - The modern RCA equivalent would be:
    - The engineers and production workers sat at the table and realized the root cause was….
- Looking at the failed part provides data.
  - Hypotheses can then be generated while sitting around a table.
    - And evaluated with empirical data, not at the table.
  - “When you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind......”
    ~ Attributed to William Thomson, Lord Kelvin

Root Cause Analysis

- An RCA needs to be empirical.
  - The concepts to achieve this exist already.
    - The scientific method.
    - Box’s iterative inductive-deductive process.
    - Deming’s Plan-Do-Check-Act.
  - These three concepts can be combined into one simple, and easy to use approach to RCA.

Root Cause Analysis

- The scientific method
  - Exploratory data analysis (EDA) can be used to generate data that can be empirically investigated.
  - A tentative hypothesis is formed based on the available data.
    - A hypothesis should be simple and general.
      - A hypothesis should not make too many assumptions.
        - Occam's Razor: The simpler of two competing hypotheses should be selected.
    - A hypothesis must also be refutable.
      - A hypothesis that can't be disproven can't be evaluated.
    - A hypothesis should predict.
      - "If one knows something to be true, he is in a position to predict; where prediction is impossible, there is no knowledge." -Adriaan D. de Groot.

Root Cause Analysis

- Objectivity is needed when using the scientific method.
  - P.B. Medawar reminds us that experimenters "must be resolutely critical, seeking reasons to disbelieve hypotheses, perhaps especially those which he has thought of himself and thinks rather brilliant.”
  - Richard Feynman tells us to avoid preferring one result over others.
    - Maybe the results we like are just the results of dirt falling into the experiment.
    - The accurate results may be discarded because they were not what the experimenter wanted to see.
  - Blinding can help prevent the inadvertently selecting the results we prefer.
    - Having a second person who interprets our results can help.

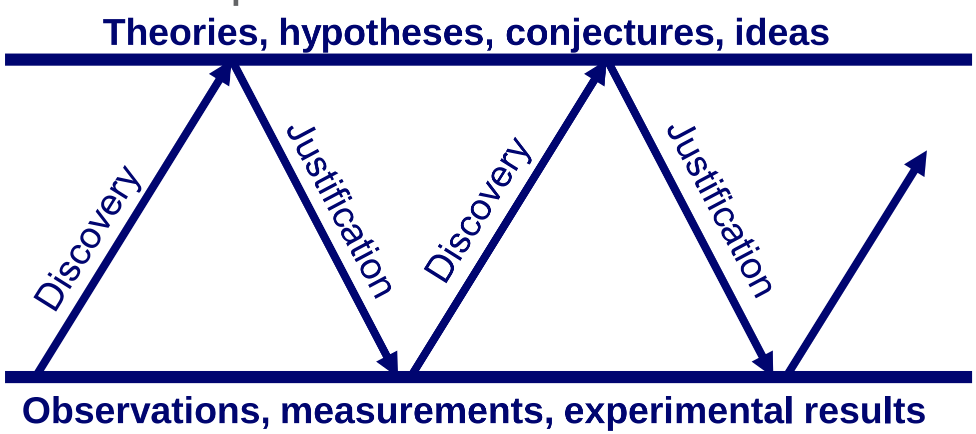
Root Cause Analysis

- The scientific method as described by John Platt's strong inference (SI).
  - Devise a hypothesis.
  - Devise a crucial experiment (or several of them), with outcomes that will exclude one or more hypotheses.
  - Cary out the experiment to get a clean result.
  - Repeat the procedure.
- Experimentation is sometimes necessary during root cause analysis.
  - Attempting to recreate a failure under simulated conditions can often be informative.
    - The experiment may not lead directly to the root cause, but it could eliminate potential root causes.
    - Be sure to control your variables.
    - Don't change all variables at once.

Root Cause Analysis

- Box's iterative inductive-deductive process.
  - Deduction is used to form a hypothesis based on what is known.
    - Deduction forms a conclusion based on general premise.
  - Induction is used to form a new hypothesis based on what is observed.
    - Induction uses empirical data to form a general conclusion.
  - The process is repeated until the root cause is discovered.

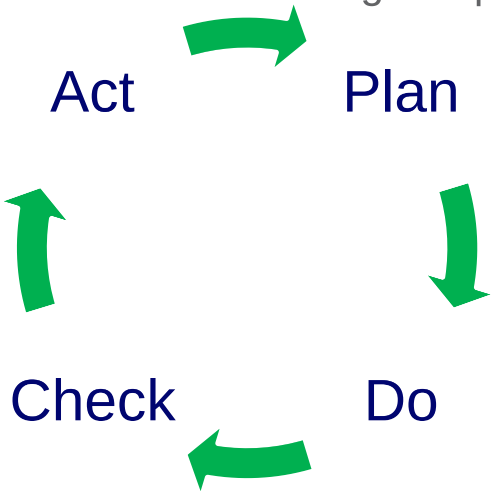
de Mast and Bisgaard's sawtooth model of inquiry



See Box, Hunter and Hunter's *Statistics for Experimenters*, published by John Wiley & Sons in 2005 for the iterative inductive-deductive process illustration.

Root Cause Analysis

- Deming's Plan-Do-Check-Act (PDCA)
  - Also an iterative process; typically used for quality improvements.
  - Can also be applied during an RCA.
    - Plan: Describe the problem and gather data to form a tentative hypothesis.
    - Do: Test the hypothesis.
    - Check: Check the results and form conclusions.
    - Act: Verify the root cause and begin improvements or repeat the process.

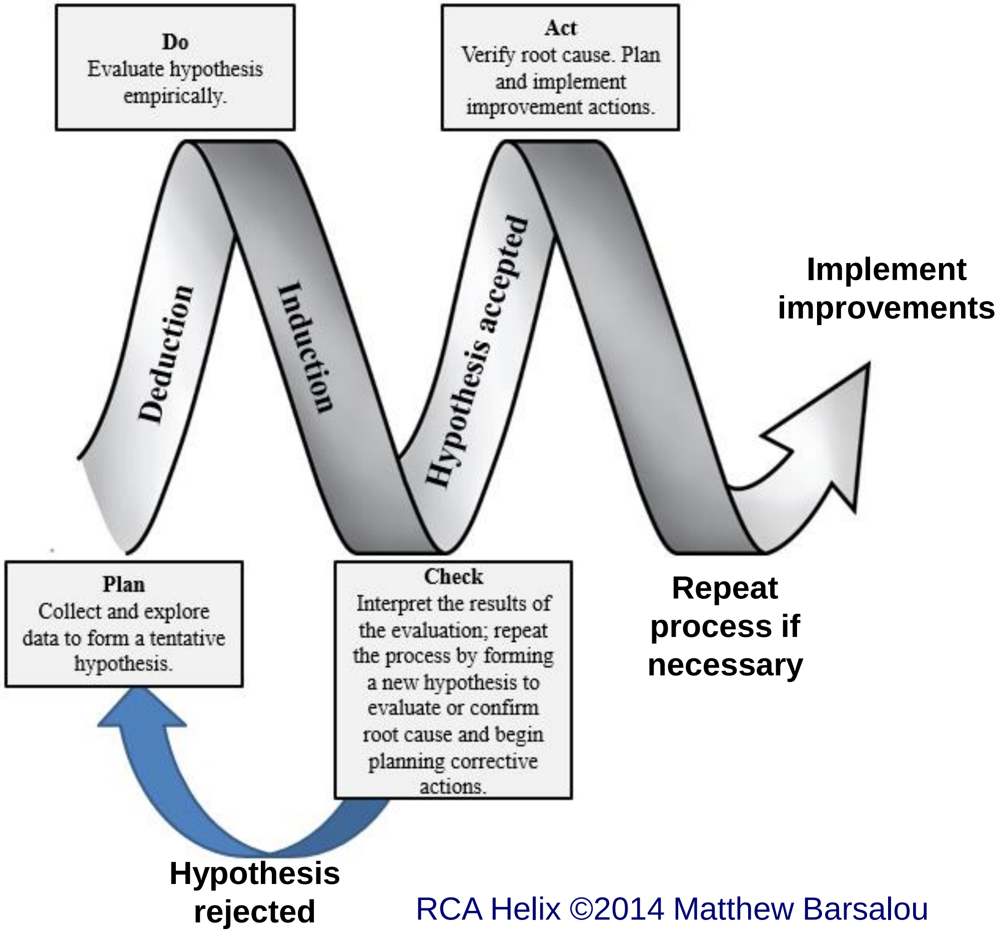


Root Cause Analysis

- EDA and the scientific method can be combined with the iterative inductive-deductive process as a part of PDCA.
  - “It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.” –Sir Arthur Conon Doyle.
  - Data is gathered and explored graphically.
  - A hypothesis is formed using induction.
  - This is then evaluated empirically.
  - If the root cause is not identified, deduction is used to form a new hypothesis and the cycle repeats.

Root Cause Analysis

- RCA helix combining PDCA, SI, EDA and Box's iterative inductive-deductive process.



RCA Helix ©2014 Matthew Barsalou

Root Cause Analysis

- The case of the cracked cable.
  - A heavy duty banded-wire cable with a coating was experiencing cracks in the coating.
    - Problem had occurred for several years.
    - The problem never occurred in test samples.
  - An experiment with different coating types was planned, but canceled because the labels were not attached to the cables.
  - The ends were cut open and metal connections removed.
    - Every cable observed was cracked in the same spot under the metal connector starting at the edge of a metal tie down strap.
    - Additional cables checked experienced the same condition.
    - Engineering change order issued to start the coating behind the end of the strap.

Root Cause Analysis

- The case of the vibration sensor failures.
  - A vibration sensor was being returned by the customer.
    - The sensor consisted of a metal casing with a spring-mounted magnetic mass moving within a coil to generate a signal.
  - The top hypothesis was "dents in the casing form mounting screw are restricting movement of the magnetic mass.
    - The hypothesis was quickly rejected by intentionally denting the cases; this did not impede normal function of the device.
  - A quick elimination of the incorrect hypothesis permitted the investigation to continue.

Root Cause Analysis

- “Something is wrong, we don’t know what it is or what part is affected, but you need to do something about it.”
  - A supplier may have difficulties responding to a warranty issue if insufficient information is available.
    - The supplier’s actions should be based upon facts.
      - To get facts, we must have data.
    - Valuable reaction time can be lost in seeking simply to identify “what happened” and “which part is it?”

Root Cause Analysis

- A customer issuing a complaint must provide the supplier with:
  - Part numbers: It is difficult to take actions when the supplier does not know which part is being claimed.
  - Number of parts found: Can this be a one-off or a systematic failure?
  - Inventory level: Necessary for planning immediate actions.
  - Clear photos: Blurry photos serve no purpose.
  - Sample parts: Critical for analyzing the issue.
  - Additional information if it is available.
  - The supplier must request this information if it is not made available.

Root Cause Analysis

- The supplier can help to minimize the effects of a failure by preparing in advance:
  - Ensure a method is in place for the quick recall of a sample part for analysis.
  - Maintaining a list of capable sorting/inspection companies near the customer.
    - Helps to ensure a quick start of sorting, but can also be used for providing additional details regarding the claimed part.
  - Ensuring in-house personnel are trained and capable of performing a root cause analysis.
  - Establishing a validated procedure for dealing with quality issues.
    - Training employees in the procedure.

References

- Barsalou, Matthew. May 2014a. “Mix it Up.” *Quality Progress* 47, no. 5: 63.
- Barsalou, Matthew. 2014b. *Root Cause Analysis: A Step-By-Step Guide to Using the Right Tool at the Right Time*. New York: Productivity Press.
- Box, George E.P., Stuart Hunter and William G. Hunter. 2005. *Statistics for Experimenters: An Introduction to Design, Data Analysis and Model Building* (2nd ed.). Hoboken, NJ: John Wiley & Sons.
- de Groot, Adriaan D. 1969. *Methodology: Foundations of Inference and Research in the Behavioral Sciences*. The Hague: Mouten.
- de Mast, Jeroen and Søren Bisgaard. 2007. “The Science in Six Sigma.” *Quality Progress* 40, no. 1: 25-29.
- Deming, W. Edwards. 1994. *The New Economics: For Industry, Government, Education* (2nd ed.). Cambridge, MA: The MIT Press.
- Doyle, Sir Arthur Conan. 1994. A Scandal in Bohemia in *The Adventures of Sherlock Holmes*. London: Penguin Books.

References

- Feynman, Richard P.1988. *The Meaning of it All: Thoughts of a Citizen-Scientist*. Reading, MA: Perseus Books.
- Medawar, P.B. 1990. *The Threat and the Glory: Reflections on Science and Scientists.* New York: Harper Collins.
- Platt, John R. 1964. “Strong Inference.” *Science* 146, no. 3642: 347-353.
- Popper, Karl. 2007. *The Logic of Scientific Discovery.* London: Routledge.
- Quine, W.V. and J.S. Ullian. 1978. *The Web of Belief,* (10th ed.). New York: Random House.
- Shainin, Dorien. 1991. Quoted in Bhote, Keki R. *World Class Quality: Using Design of Experiments to Make it Happen*. New York: AMACON.
- Tukey, John W. 1977. *Exploratory Data Analysis*. Reading, MA: Addison-Wesley.

Thank You


feel good
about driving
better fuel economy
reduced emissions
great performance